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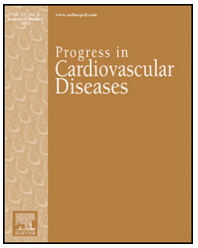

Part 1: Potential Dangers of Extreme Endurance Exercise: How Much Is Too Much? Part 2: Screening of School-Age Athletes

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ABSTRACT

The question is not whether exercise is or isn't one of the very best strategies for improving quality of life, cardiovascular (CV) health and longevity—it is. And there is no debate as to whether or not strenuous high-intensity endurance training produces an amazingly efficient, compliant, and powerful pump—it does. The essence of the controversy centers on what exactly is the ideal pattern of long-term physical activity (PA) for conferring robust and enduring CV health, while also optimizing life expectancy. With that goal in mind, this review will focus on the question: "Is more always better when it comes to exercise?" And if a dose–response curve exists for the therapeutic effects of PA, where is the upper threshold at which point further training begins to detract from the health and longevity benefits noted with moderate exercise? The emerging picture from the cumulative data on this hotly debated topic is that moderate exercise appears to be the sweet spot for bestowing lasting CV health and longevity. However, the specific definition of moderate in this context is not clear yet.

Part 1

Exercising for peak fitness versus health and longevity

Physical exercise when performed regularly is one of the best strategies for enhancing quality of life, improving CV health and lengthening life expectancy.[1–3] However, emerging scientific evidence indicates that exercise practices that are ideal for conferring CV health and longevity may differ from the high-intensity, high-volume endurance training programs that are effective for developing peak cardiac performance and elite-level cardiorespiratory fitness (CRF).[4] Progressively enhancing CRF levels from low to moderate to high will proportionately improve CV prognosis and overall life expectancy.[5] However, the longevity dividends related to incremental increases in CRF plateau at about 10 metabolic equivalents (METS), with no further rise in life expectancy accruing from higher levels of CRF.[5–7] Although a regimen of 30 min of moderate or vigorous physical activity (PA) on most days of the week will improve health and well-being, increasing the dose of exercise to daily

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Abbreviations and Acronyms

AF = atrial fibrillation

ARVD = arrhythmogenic right ventricular dysplasia

BNP = B-type natriuretic peptide

CAC = coronary artery calcification

CHD = coronary heart disease

CRF = cardiorespiratory fitness

CT = computed tomography

CV = Cardiovascular

ECG = electrocardiogram

HCM = hypertrophic cardiomyopathy

MI = myocardial infarction

PA = physical activity

RA/LA = right and left atria

RV = right ventricle

SCD = sudden cardiac death

US = United States

VT = ventricular tachycardia

multi-hour bouts of strenuous exercise will not magnify the health benefits. In fact, an evolving body of evidence suggests that excessive doses of exercise may trigger acute transient myocardial dysfunction with subsequent pathological rises in levels of cardiac troponin and B-type natriuretic peptide (BNP).[8,9]

Exercise and survival: more is not always better

Epidemiological studies of healthy populations have found reverse-J-curve or U-curve relationships for exercise dose and long-term CV health and life expectancy.[10–12] Moderate exercise, as compared to a sedentary lifestyle, markedly lowers the risk for CV events and all-cause mortality.[10–12] However, progressively excessive regimens of chronic endurance exercise partially erase the longevity benefits associated with light and moderate exercise regimens.

The aerobics center longitudinal study

An important recent study by Lee, Lavie and colleagues focused on the mortality effects of running among a cohort of 55,000 adults ages 18 to 100 years followed for a mean of 15 years.[13] Using comprehensive analyses that controlled for potential confounding factors, they found that runners (as compared to non-runners) had 30% and 45% lower risks of all-cause and CV mortality, respectively, with a mean improvement in life expectancy of 3-years. However, the maximal CV longevity benefits were noted with moderate doses of running: specifically 6 to 12 miles run per week, with running durations of about 50 to 120 min per week, with a running frequency of about 3 times per week, and a modest pace of about 6 to 7 miles per hour. Higher weekly doses of running were associated with loss of approximately one-third to one-half of the CV mortality benefits noted from the moderate doses of running (Fig 1 A and B).

The copenhagen city heart study

In this prospective longitudinal study, 1098 healthy joggers and 3950 healthy non-joggers were followed for 12 years.[14] The cohort of individuals jogging 1 to 2.4 h per week had a 50% lower mortality rate compared to the sedentary control group. In this study, the optimal frequency of jogging was from 2 to 3 times per week, and the optimal running speed was either a slow or average pace. When the joggers were divided into 3 groups – light, moderate, or strenuous – according to running dose (as calibrated by pace, jogging duration, and frequency of runs), a U-shaped association between all-cause mortality and running dose was apparent. Light and moderate joggers had lower mortality rates than sedentary people; in contrast, strenuous runners had a mortality rate statistically similar to the sedentary group (Fig 2).

Exercise dose–response curve among coronary disease patients

A study utilizing the National Walkers' and Runners' Health Studies database followed 2377 survivors of myocardial infarction (MI) with the goal of assessing the dose–response relationship between exercise and long-term CV mortality.[1] Compared to a sedentary lifestyle, a regular regimen of running or walking was associated with progressive dose-dependent reductions in CV mortality. Maximal benefits, including up to 65% reductions in CV mortality, were seen among cohorts running 20 to 30 miles (32 to 48 km) per week, or walking 35 to 45 miles (56 to 73 km) per week. However, for cohorts who were exercising above these thresholds, much of the CV mortality benefit was lost in a U-curve pattern (Fig 3). Of interest, this data set from the National Walkers' and Runners' Health Studies confirmed prior reports indicating that the CV longevity benefits of walking and running were equal as long as the number of calories burned during exercise – energy expenditures – was equivalent.[1] For example, the duration of exercise required to burn 300 cal will be about twice as long for walking (about 50 to 60 min) compared to jogging (about 25 to 30 min).

Another very recent cohort study reported a reverse-J-curve pattern for exercise among 1038 individuals with stable coronary heart disease (CHD).[2] This study also found that inactive individuals were at the maximum risk for adverse health outcomes, with the moderate exercise cohort at the lowest risk. Intermediate in risk was the most physically active cohort (those doing strenuous exercise on a daily basis), who displayed a risk of CV mortality that was higher than the moderately active cohort, but not as high as the sedentary cohort. Over the 10-year follow-up period, that study found that the sedentary cohort was at 2-fold increased risk of MI or stroke and 4-fold higher risk of all-cause mortality compared with the moderately active group. However, the cohort who performed strenuous exercise on a nearly every day basis was also at higher risk—showing a 2-fold risk of fatal MI or stroke compared to the moderately active cohort.[2]

Exercise and atrial fibrillation

A growing number of epidemiological and observational studies consistently report strong statistically significant associations between chronic high-intensity endurance exercise and a higher risk for atrial fibrillation (AF).[15–18] The